Docket #71034

BALL-AND-SOCKET JOINT AND BALL-AND-SOCKET JOINT BEARING SHELL

FIELD OF THE INVENTION

[0001] The present invention pertains to a ball-and-socket joint, preferably for motor vehicles, in which a joint ball formed on a pivot pin is mounted movably in a bearing shell consisting of a plastic or other similar material and the bearing shell is surrounded with a housing which provides support to the assembly. The invention also pertains to a process for forming a ball-and-socket joint.

BACKGROUND OF THE INVENTION

[0002] Such ball-and-socket joints of this type are widely used in mechanical engineering, especially in the automotive industry. Ball and socket joints are often made of a housing part that is generally tubular or cup shaped and includes a bearing shell (race insert) that

is positioned within the housing part. Additionally, an end plate is sometimes used to close one end of the structure and a bellows (boot) is used connected to the bearing pin and to the housing at the other end. Other structural parts are provided for sealing connections. These include a boot seal or bellows seal structure that provides a seat for the bellows and provides a sealing function. Some ball and socket joints also include further sealing structures cooperating with the bearing shell or otherwise provided to maintain protection in the region of the ball joint.

[0003] A ball-and-socket is known from DE 296 07 587.6 & DE 296 16 350.3. Such ball-and-socket joint has a ball surrounded by a bearing shell which is molded-in-place or cast in place. To create the joint, a joint housing is held fixed in place and a ball portion of a bearing pin is located within the joint housing with the bearing pin being fixedly held in place to maintain location of the ball portion within the joint housing. A material is then molded-in-place (such as by injection molding) or cast in place between the joint housing and ball portion thus forming the bearing shell.

[0004] Prior art constructions have proven quite effective in use. However, most designs require significant numbers of manufacturing steps and some sophisticated designs are quite labor-intensive with regard to manufacturing.

SUMMARY OF THE INVENTION

[0005] It is an object of the invention to provide a ball-and-socket joint that may be manufactured economically with few steps and is simple in design and rugged in construction.

According to the invention to a ball-and-socket joint for motor vehicles or similar applications has a joint ball incorporated as part of a pivot pin. The pivot pin is commonly used as a mounting for the ball-and-socket joint to a control arm or other component of a motor vehicle. A joint ball resides within the ball-and-socket joint and acts as the point around which the ball-and-socket joint allows articulation. A housing is formed of a shaped metal tube. The housing has a top end with an opening and an end, opposite to the top end, with an opening through which the pivot pin protrudes for connection with the vehicle component. A material molded directly on the housing is used to form a functional surface or surfaces on the inside of the housing where the functional surface serves as a bearing shell for the joint ball, and or on the outer surface of the housing where the molded material can serve as a mounting for a bellows, or other type of sealing element.

[0006] The molded material forming the inner and outer functional surfaces can be continuous and follow around an edge of the housing as it transitions from one surface to another. Molded in ties can be formed in the molded material, these ties passing through openings or holes in the housing part, thus connecting the inner and outer functional surfaces, positively locking them in relation to the housing part. The bearing shell surface can likewise form a bearing surface for the joint ball which is a contact surface in contact with effectively the entire usable bearing surface of the joint ball.

[0007] Extension segments (petals) of the molded material can be formed, integral with the molded material and extending from a region of the bearing shell portion of the molded

material. The petals utilize an integral hinge or flexible section so they may be folded about the joint ball after the joint ball is inserted into the bearing shell portion of the molded part. The petals, after being folded over, form a remainder of the bearing shell surface in functional contact with the joint ball. The petals are molded with a concave shape on their inner surface so as to correspond to the shape of the joint ball to which they will interface. Often the joint ball will contact the bearing shell and petal surfaces in less than the entire usable joint ball bearing surface.

[0008] As an alternative to the petals being folded into functional contact with the joint ball, a bearing shell insert can be inserted in the housing adjacent to the molded bearing shell portion. The bearing shell insert may have a bearing surface which cooperates with the molded part to form an adequate bearing interface surface for the joint ball to bear on.

[0009] As a further alternative, the molded part forming part of or the entire bearing surface can be molded outside the housing and then inserted with, or inserted before, the joint ball into the housing.

[0010] An end cap may be used to close the opening in the housing top end after insertion of the molded bearing shell and any other bearing shell forming parts, along with the joint ball/pivot pin, into the housing. The end cap is held in place in the opening by a rolling over lip which is rolled over or pressed onto the perimeter of the end cap to retain the end cap in place, thus closing the opening. The end cap can also provide a pre-load on the molded part (bearing

shell) against the joint ball to achieve a desired force requirement for movement of the joint ball relative to the bearing shell in rotation and pivoting alike. The folded area can be pressed or crimped onto a lip incorporated into the molded part to lock the molded part to the housing after molding in place or insertion of the molded part.

[0011] Ribs or other surface texturing features such as knurling can be incorporated into the inner surface of the housing part. The ribs are located in the areas where the molded part is either molded to the housing, or where the molded part, if pre-molded outside the housing, is to come into contact with the housing part. The ribs form an interference fit with the molded part, biting into the molded part and thus preventing a rotation of the molded part relative to the housing as the ball-and-socket joint is used. Ribs may also be used on the outside of the housing part to form an interference fit with the component into which the joint is being mounted. This interference fit prevents a rotation of the housing relative to the component into which it is mounted.

[0012] Manufacturing of the ball-and-socket joint can be performed starting with a tube which is rolled, spun or hydroformed etc. into a profiled tube comprised of repeated formed sections of housing parts. These sections are then cut to form individual housing parts. In comparison to traditional forming methods, which can also be used to manufacture the housing parts, the cutting of the individual housing parts from the profiled tube avoids the waste associated with flange areas of traditional stamping processes.

[0013] The individual housing part is then placed in a mold space or fixture where material is injection molded, or otherwise molded, or cast, into the space provided in the mold between an inner mold contour and outer mold support elements onto surfaces of the housing part. The resulting part molded onto the housing part has the functional surfaces incorporated therein to interact with the joint ball as the bearing surface upon which the joint ball acts. A boot groove for the retention of a sealing bellows may be incorporated into the molded part in addition to the joint ball surface and any other functional surfaces of the molded part. The molded part may wrap around the lip of the housing part as it transitions from one functional surface to the next. Holes or openings in the housing part may be incorporated. The holes provide a pass through for the molded material to join during molding from the outside of the housing part to the inside of the housing part thus forming ties. The ties help to affix the inner and outer functional surfaces of the molded part to each other, to resist separation from the housing part, and to prevent a rotation of the molded part relative to the housing part.

[0014] The molded part may also be molded as a component separate from the housing part, and then inserted into the housing part either prior to or in conjunction with the insertion of the joint ball. A second molded part can also be used to provide functional surface area for the joint ball where the molded part does not provide the entire bearing area needed for the joint ball.

[0015] The various features of novelty which characterize the invention are pointed out with particularity in the claims annexed to and forming a part of this disclosure. For a better understanding of the invention, its operating advantages and specific objects attained by its uses,

reference is made to the accompanying drawings and descriptive matter in which preferred embodiments of the invention are illustrated.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] Figure 1 is a perspective view of tubing used in a process according to one embodiment of the process of the invention;

[0017] Figure 2 is a partial sectional view of the tube of Figure 1 after a stamping or other shaping procedure;

[0018] Figure 3 is a sectional view showing the machined tube of Figure 2, indicating locations for cutting;

[0019] Figure 4 is a sectional view showing a further shaping procedure for a housing part of the ball and socket joint according to the invention;

[0020] Figure 5 is an illustration of further shaping procedure according to an embodiment of the process of the invention;

[0021] Figure 6 is a sectional view of a housing part for the ball and socket joint according to the invention;

[0022] Figure 7 is a sectional view showing a molding procedure with surface portions molded upon the housing part;

[0023] Figure 8A is a sectional view showing the particulars of the molded portion according to an embodiment of the invention;

[0024] Figure 8B is an perspective view of the molded part according to the embodiment of Figure 8A;

[0025] Figure 9 is a top view of the embodiment Figure 8A;

[0026] Figure 10 is a top view of an alternative to the embodiment of Figure 9;

[0027] Figure 11 is a perspective view of the embodiment of Figure 8A showing a stage of the manufacturing process according to the invention;

[0028] Figure 12A is a sectional view illustrating a step in the manufacturing process for forming the ball and socket joint according to the embodiment of Figure 8A;

[0029] Figure 12B is a sectional view illustrating another step in the manufacturing process for forming the ball and socket joint according to the embodiment Figure 8A;

[0030] Figure 12C is another sectional view illustrating another step in the manufacturing process for forming the ball and socket joint according to the embodiment of Figure 8A;

[0031] Figure 13 is a sectional view of the final assembled ball and socket joint according to the embodiment Figure 8A;

[0032] Figure 14 is the exterior view of the assembled ball and socket joint according to the embodiment of Figure 8A;

[0033] Figure 15 is a sectional view showing an assembled ball and socket joint according to an alternative embodiment of the invention;

[0034] Figure 16 is a cutaway sectional view showing an assembled ball and socket joint according to another alternative embodiment;

[0035] Figure 17A is a sectional view showing an assembled ball and socket joint according to another embodiment of the invention produced by an alternate process according to the invention;

[0036] Figure 17B is an enlarged detailed sectional view of the embodiment of Figure

17A;

[0037] Figure 18A is a sectional view of a one-piece bearing shell according to another embodiment of the invention;

[0038] Figure 18B is a sectional view showing an assembled ball and socket joint using the bearing shell of the embodiment Figure 18A;

[0039] Figure 19A is a sectional view of the housing part in a press forming step;

[0040] Figure 19B is a sectional view of the housing part similar to that of Figure 19A;

[0041] Figure 20 is a perspective view of the housing part with outer ribbing;

[0042] Figure 21A is a view of a ribbed housing part prior to insertion of a molded part;

[0043] Figure 21B is a view of the components of Figure 21A after assembly;

[0044] Figure 22A is a view of the joint showing the end cap with the rolled over edge shown in dashed lines;

[0045] Figure 22B is a sectional view of the housing part prior to folding over of an edge

on the molded part; and

[0046] Figure 22C is a sectional view of the components of Figure 22B after folding of the folding over edge.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0047] Referring to the drawings in particular, Figure 1 shows tubing 5 that can be used according to a process for forming a ball and socket joint according to the invention. The tubing 5 is shaped in a shaping process to produce a shaped tube generally designated 7 (Figure 2). The shaping process of the tube may utilize techniques such as hydroforming, rolling, etc.. The shaped tubing 7 includes contours such as contour 9 forming the base for a bellows support groove. As illustrated in Figure 3 the shaped tube 7 is cut at cutlines 11 to form several housing parts 10 of a desired length. The cutting of the tube may also be done in such a manner that a section of scrap material between the housing parts 10 is removed. This section of scrap material may be utilized to absorb excess runout material resulting from the forming process for the housing parts 10 and to allow for tolerances in the manufacturing process. As an alternative to forming a shaped tube which is subsequently cut into individual housing parts 10, the housing parts 10 may be formed individually by numerous metal forming processes known in the art.

[0048] To provide a further shaping to the housing part 10, the housing part 10 is subjected to a stamping procedure or other shaping procedure as illustrated in Figures 4 and 5. The support 12 is provided and optionally an interior support 14 is also provided to support the

housing 10. The supports 12 and 14 interact with a press 16. This results in a stamped flange contour 18 as can be seen in Figure 6. As shown in Figure 5, the interior support sets the press fit diameter and corner radius of the interior of the housing part 10, while the support 12 supports the outside diameter of the housing part and the flange contour 18. The housing part 10 may optionally be cleaned after forming to remove greases, oils, and any other contaminants which may adversely affect subsequent manufacturing process, in particular the adhesion of molding or coating materials to the housing part 10.

[0049] The housing part 10 is disposed at least partially in a mold 15 as shown in Figure 7. The mold 15 has support surfaces for supporting the housing part. The support surfaces may include a support or supports of the exterior of the housing 10 which are not to receive a molded part. This supports the housing part 10 in the mold relative to the mold space. Injectable material is then injected into the mold space to form a molded part 20 with functional surfaces formed by injection molded material. As an alternative to injection molding of material to form part 20, casting, compression molding or other methods known in the art may be utilized to form the molded part 20. The functional surfaces of the molded part 20 include a race surface or bearing surface 24 for the ball 3 as well as a sealing boot groove or bellows seal seat 22. The functional surfaces also may include functional surfaces formed for interaction with the pivot pin 2 and with a top of the ball 3 as shown in Figure 13. In the embodiment of Figure 13 (see also Figure 8A and the molding step of Figure 7) the bearing surfaces for interaction with the top of the ball 3 are provided by integrally formed petals or segments 26. Other functional surfaces may be provided including surfaces for lubricant sealing at the race or near the pivot pin 2 of the

ball pivot 1.

[0050] Figure 8A depicts the ball 3 seated in the bearing surface 24 of the molded part 20 from the molding procedure of Figure 7. The housing part 10 now has the molded part 20 molded onto it. The molded part includes a folded area 28 connecting the segments 26 to the remaining portion of the molded part 20. The segments 26 are fold at the folded area 28 to provide an upper bearing surface for the ball part 3 of the ball pivot 1.

[0051] Figure 8B illustrates the feature of the segments 26 and illustrates the direction of folding of the segments 26 with respect to the folded area 28. The process including the molding procedure of Figure 7 results in an integral unit that provides bearing surfaces at an upper portion, at a middle portion and at a lower portion of the ball pivot 3 (full bearing surface or race) as well as the boot groove or seat 22 for the upper portion of the bellows seal 34 as shown in Figure 13.

[0052] The segments 26 allow for a manufacturing process in which a single injection or otherwise molding step forms the various surfaces as noted above. The segments 26 may be provided in a convenient number such as the six segments 26 shown in Figure 9 or the four segments 26 shown in Figure 10. The exact number of the segments may be related to the diameter of the over all bearing which is available. The number of petals or segments 26 can also be related to the diameter of a rollover lip/edge 32 of the housing part 10 (see Figure 11). The number of segments 26 may also be selected to optimize the overall ball and socket joint

with regard to torques and elasticities.

[0053] The segments themselves are preferably slightly curved as shown in Figure 8A relative to the remainder of the molded part 20. The folded area 28 may also include a curved section in the transition between the segment 28 and the remaining portion of the molded part 20. A slight curve to the structure results in segments being pulled down slightly as the ball is popped into the bearing surface 24. This is based on insertion of the ball 3 from the top as shown in Figure 12A. Depending on the particular design, grease grooves may not be necessary in the molded part 20, thus allowing more of the bearing surface 24 to contact the ball 3, in turn providing greater wearing life for the joint.

[0054] Figure 11 is a perspective view showing the housing part 10 with the molded part 20 molded thereto showing the bellows seat 22 as well as the segments 26. The rollover lip 32 is shown in a position ready to interact with an end cap 30 as shown in Figure 12C.

[0055] The closure of the housing with the end cap 30 after the insertion of the ball pivot 1 is illustrated in Figures 12A, 12B and 12C. As shown in Figure 12A the ball pivot 1 is inserted into the assembly of Figure 11 with the ball 3 urging the segments 26 into an open position. The segments 26 pivot or flex at the folded area 28 as the ball 3 is inserted into the interior of the housing 10. As the pivot pin 2 is extended through the housing and the ball 3 is popped into position the segments 26 are pulled somewhat into position as shown in Figure 12B. This pulling of the segments 26 is based on the integral nature of the molded part 20 and is based on

the shape of the segments 26 and folded area 28 as described above. As shown in Figure 12C the end cap 30 pushes down upon the segments 26. The roll over portion 32 (as shown in Figure 13) then rolls over the edge of the end cap 30. The roll over process may also be used to influence the torques and elasticities of the resulting construction based on the large influence of the end cap 30 pressing the segments 26. The torques and elasticities may be measured during the application of force on the end cap 30 until the desired range is reached and this range may be set by rolling over the edge 32 to freeze the joint at the selected values of torques and elasticities.

[0056] The shape of the segments 26, particularly the interior facing bearing surface, can be varied in order to optimize the wear of this bearing surface. It is also possible to vary the force applied to the end cap 30 to optimize the wear of the bearing surface 24 and the bearing surface of segments 26. During the procedure shown in Figures 12A – 12C or prior to that, grease or another lubricant may be inserted into the region of the bearing surface 24. The bearing surface 24 may also have grooves, or other cavities, to hold grease.

[0057] An assembled ball and socket joint is shown in Figure 13. A bellows or boot 34 is applied with a closure ring 38 to the pivot 2 of the ball pivot 1. The other end of the bellows 34 is connected to the boot or the bellows seat 22 via a holding ring 36. The rollover edge 32 can be an edge of the end cap 30 to provide a closure to the interior of the ball and socket joint.

[0058] Figure 14 shows the assembled ball and socket joint of Figure 13 in a side view. Figure 14 shows the bellows 34 as well as the ring 38 and ring 36. Additionally a small portion

of the molded part 20 can be observed, namely the portion at the upper edge of the surface 22. The end cap 30 is shown closed off by the rollover edge 32.

[0059] Figure 15 shows an alternative design. The embodiment of Figure 15 is formed in manner similar to the embodiment of Figure 13. However, the molded part 40 is different form the molded part 20 of Figure 13.

[00]60 Molded part 40 includes a lower portion with the bellows seat 42. However, the race or bearing surface 24 is provided with a continuous upper and lower portion. The upper portion 46 is not segmented. With this design the ball 3 must be popped or forced into the single unsegmented molded piece 40. The end cap 30 is applied as shown in Figure 15. The end cap 30 provides a closure and gives support to the unsegmented upper portion 46.

[0061] Figure 16 shows still another embodiment of the ball and socket joint according to the invention. A molded part 50 is provided following a process similar to that described with reference to Figure 7. However, the molded part 50 is provided along only a portion of the interior of housing part 10. As such, the molded part 50 forms only a lower bearing surface portion 54, forming only a portion of the overall race or interior bearing surface. Another molded race portion 56 (also made of plastic such as an injectable material) is inserted into the housing part 10 subsequent to inserting the ball pivot 1 to position ball 3 in the housing. The molded part 50 also includes the bellows seat surface 52 (the boot groove).

[0062] Figure 17A shows still another embodiment of the invention. A housing part 60 is formed by a stamping procedure. The housing part 60 is a cup shaped structure with a stamped or shaped flange part 68 as well as rollover edge 62. This housing part 60 is inserted into a mold following a procedure similar to that described with reference to Figure 7. This results in a molded part 70 which includes various functional surfaces. The functional surfaces include for example the race or bearing surface 76 in the interior of the housing 60 as well as a bellows seat (boot groove) 72. The molded part 70 is an integral structure based on passages 64 which are filled with injection molded material and form an integral structure (connected at both sides through the passages 64). The rollover edge 62 provides a retaining function and extra support to the molded part 70, supporting the race surface 76. The through holes or passages 64 are best seen in Figure 17B. Instead of the housing part 70 being rolled over the race portion 74 (providing support for the race portion 74) a ring may also be provided. The embodiment of Figure 17A requires a popping in of the ball 3 into the housing 60 based on the integral nature of the upper bearing portion 76 in the remainder of the bearing surface 74.

[0063] Figure 18A discloses an alternative embodiment in which a molded part 80 is formed as a separate molded part. The molded part 80 includes interior bearing surfaces or race surfaces 84 and also includes integral attached segments 86 attached to a remainder of the molded part 80 by folded part 88. The structure is formed as a single integral piece molded as a separate element from a housing part 90. The molded part 80 is positioned within the housing part 90. The housing part 90 may also include functional surfaces such as a bellows seat (boot groove) 94. After disposing the molded part 80 within the housing part 90, the ball 3 of the ball

pivot 1 is inserted into the housing with the ball 3 in contact with the bearing surfaces 84. An end cap 30 is then applied and rollover edge 92 closes the assembly. The petals or segments 86 are positioned with an interior bearing surface in contact with an upper portion of the ball 3.

[0064] Figures 19A and 19B show incorporation of housing interior ribbing 96 formed on the interior surface of the housing 10. The housing interior ribbing 96 is formed as the interior support is pressed into the housing part 10 during manufacture, where interior support ribbing 97 on the interior support 14 forms the housing interior ribbing in the housing. Knurling or other surface disruption methods may also be used in place of ribbing. The housing interior ribbing is used to form an interference fit with the molded part 20 as the molded part 20 is inserted into the housing part 10. The interference fit between the parts prevents the molded part 20 from rotating relative to the housing part 10.

[0065] Figure 20 shows a housing part 10 with housing outer ribbing 98. The housing outer ribbing 98 is formed in a manner likewise to that used to form housing inner ribbing except that ribbing on the support 12 is used to form the housing outer ribbing 98 during pressing of the housing part 10. The housing outer ribbing is designed to provide an interference fit between the housing and a component to which it is mounted, such as that of a tie rod end in an automobile, thus preventing a rotation of the housing part 10, and therefore the aggregate joint assembly, within the component into which it is mounted. Knurling or other surface disruption methods may also be used in place of ribbing.

[0066] Figures 21A & 21B show the housing part 10 with the housing interior ribbing 96 (as shown in Figures 19A & 19B) along with the ball 3 of the joint and the molded part 20 in both a pre assembled state (Figure 19A) and a post assembled state (Figure 19B) of the three components. During assembly the housing interior ribbing 96 cuts into the outer surface of the molded part 20 thus providing an interference fit.

[0067] Figures 22A to 22C show methods of locking the molded part 20 from ejection from the housing part 10 after insertion into the housing part 10. Figure 22A shows an end cap 30 constraining the molded part 20. The End cap 30 is then locked in place by rolling over the rollover lip 32 after placement of the end cap 30. A pre-load or force can be applied to the molded part 20 and in turn to the ball 3 by the forcing of the end cap 30 against the molded part 20 as the rollover lip 32 is rolled over. Figure 22B shows an alternate means of holding the molded part 20 in the housing part 10. A folded area 28 protrudes to catch a lip on the molded part 20. The folded area 28 is then pressed down crimping it onto the lip of the molded part 20 thus crimping it in place as shown in Figure 22C.

[0068] While specific embodiments of the invention have been shown and described in detail to illustrate the application of the principles of the invention, it will be understood that the invention may be embodied otherwise without departing from such principles.